

AD-A059 685

NAVY CLOTHING AND TEXTILE RESEARCH FACILITY NATICK MASS F/G 6/17  
THE NAVY MOD I SUBMARINE DECK EXPOSURE SUIT (PHYSIOLOGICAL, BUO--ETC(U)  
JUN 78 J SILVIA, N F AUDET, D A REINS

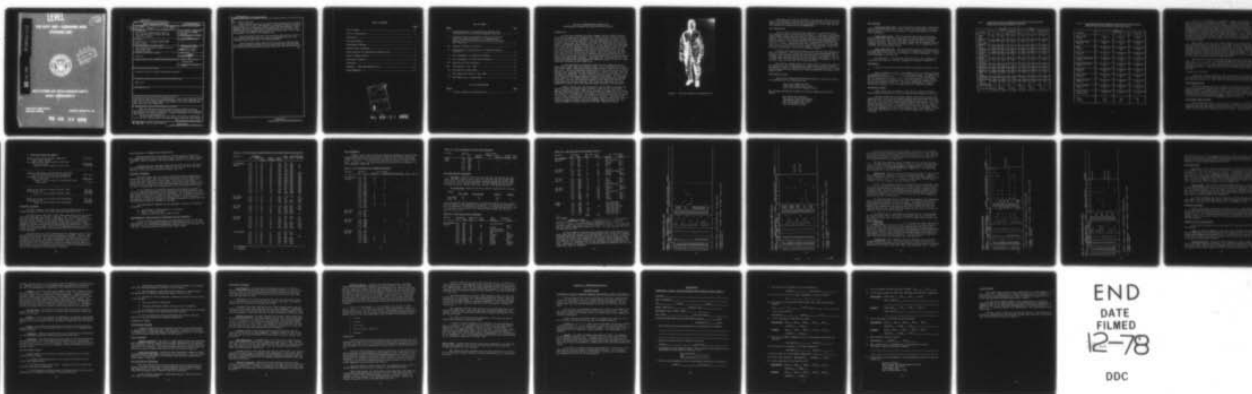
UNCLASSIFIED

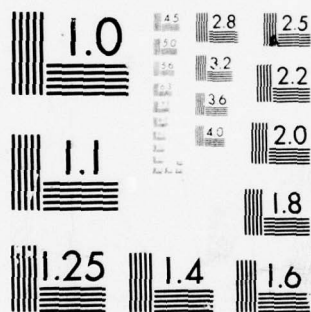
NCTRF-TR-129

NL

| OF |

AD  
A059685





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

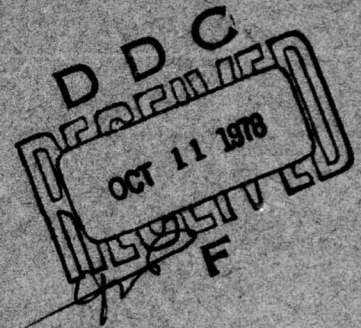
**LEVEL II**

(12)

AD A059685

DDC FILE COPY

**THE NAVY MOD I SUBMARINE DECK  
EXPOSURE SUIT**



**NAVY CLOTHING AND TEXTILE RESEARCH FACILITY  
NATICK, MASSACHUSETTS**

Approved for public release;  
distribution unlimited

TECHNICAL REPORT NO. 129

**78 09 29 002**

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER <b>NCTRF-7R-129, NCTRF-9-76</b>	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) <b>The Navy Mod I Submarine Deck Exposure Suit (Physiological, Buoyancy and Field Evaluation Studies),</b>	5. TYPE OF REPORT & PERIOD COVERED <b>Final Technical Report, 1973-1976</b>	6. PERFORMING ORG. REPORT NUMBER <b>9-76</b>
7. AUTHOR(s) <b>John Silvia, Jr., Norman F. Audet / and Dale A. Reins</b>	8. CONTRACT OR GRANT NUMBER(s) <b>16 / F51523</b>	9. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS <b>62758N-TF51523 003-31</b>
9. PERFORMING ORGANIZATION NAME AND ADDRESS <b>Navy Clothing and Textile Research Facility 21 Strathmore Road Natick, MA 01760</b>	10. REPORT DATE <b>11 June 1978</b>	11. NUMBER OF PAGES <b>35</b>
11. CONTROLLING OFFICE NAME AND ADDRESS <b>Same as 9.</b>	12. SECURITY CLASS. (of this report) <b>UNCLASSIFIED</b>	13. DECLASSIFICATION/DOWNGRADING SCHEDULE
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. DISTRIBUTION STATEMENT (of this Report) <b>Approved for public release; distribution unlimited.</b>	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) <b>Same as 16.</b>		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) <b>Submarine Deck Exposure Suits; Polyvinylchloride - Foam - Insulated Interlining; Nylon Taffeta Inner Lining; Neoprene-Coated-Nylon Outer Fabric; Immersion Test; Spray Test; Dry-Cold Exposure Test; Static Buoyancy Tests; Suit Buoyancy Test; Water Gain Test; Field Evaluations.</b>		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <b>The Navy Clothing and Textile Research Facility (NCTRF) conducted physiological studies which established that the experimental Type B Submarine Deck Exposure Suit (SDES) prototype was a possible replacement for the Interim SDES currently worn on submarines. (U)</b> <b>The Type B SDES prototype was then used as the basis for construction of the new Mod I SDES prototype, and additional Mod I prototypes were procured</b> <b>(Continued on reverse side.)</b>		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

for further studies.(U)

Static buoyancy studies of the new Mod I SDES prototype and the Interim SDES revealed that the Mod I SDES provided an additional 9 pounds of buoyancy. Buoyancy studies of a human test subject wearing each SDES immersed in water indicated that the Mod I SDES had an increased buoyancy of 20 pounds. Each SDES was worn with insulated gloves and boots and the buoyancy of these items was included in each SDES's total buoyancy. (U)

The water pickup of the Mod I and the Interim SDES used in the man-in-suit buoyancy study was found to be equal, thus negating the need of the waterproof slide fastener used in the Interim SDES.(U)

Field evaluation studies indicated that the new Mod I SDES prototype provided more thermal protection than the Interim SDES when evaluated under wet, windy sub-freezing temperatures aboard Naval and Coast Guard vessels.(U)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

# TABLE OF CONTENTS

	<u>Page</u>
List of Tables.....	iv
List of Illustrations.....	iv
Introduction.....	1
Suit Descriptions.....	3
Physiological Testing.....	3
Buoyancy Tests (In-House).....	7
Field Evaluation of Submarine Deck Exposure Suit.....	11
Activity Summary Reports.....	24
Discussion of Results.....	25
Conclusions .....	27
Appendix A. SDES Questionnaire Form.....	A-1
Acknowledgements.....	B-1

ACCESSION for	
NTIS	White Section <input checked="" type="checkbox"/>
DDC	Buff Section <input type="checkbox"/>
UNANNOUNCED	
JUS TIFICATION	
BY	
DISTRIBUTION/AVAIL ACTIVITY CODES	
SP. CIAL	
A	

iii  
 78 09 29 002

## LIST OF TABLES

<u>Table</u>	<u>Page</u>
I    Physiological Data for Submarine Deck Exposure Suits Evaluated Under the Various Environmental Conditions .....	5
II   Ranking Information and Number of Tests for Rectal and Skin Probe Temperature Data for the Submarine Deck Exposure Suits Evaluated Under the Various Environmental Test Conditions .....	8
III   Buoyancy and Water Gain Results .....	9
IV   Anthropological Characteristics of Volunteers and Suit Sizes Worn .....	12
V    Duty Assignments for Submarine Personnel .....	13
VI   Duty Assignments for Coast Guard Personnel .....	14
VII   Wear Data and Suit Preference .....	14
VIII   Cold Exposure - Mod I SDES .....	16
IX    Cold Exposure-Interim SDES .....	19
X    Warm Temperature Results - Mod I SDES .....	22
XI   Warm Temperature - Interim SDES .....	23

## LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Page</u>
1    The Navy Submarine Deck Exposure Suit .....	2

THE MOD I SUBMARINE DECK EXPOSURE SUIT  
(PHYSIOLOGICAL, BUOYANCY AND FIELD EVALUATION STUDIES)

INTRODUCTION

In 1973, Navy Clothing and Textile Research Facility (NCTRF) developed two prototype Submarine Deck Exposure Suit (SDES) coveralls (A&B) with more insulation than the interim standard which were physiologically tested in 1974, in-house, with the interim SDES suit. While no significant statistical differences were noted under the cold-dry tests (20°F air temperature and 18 mph wind speeds), performance ratings indicated that: (a) the prototype B suit performed better than both the prototype A suit and the interim SDES suit under the immersion tests (20°F air temperature, 35°F water and 18 mph wind speed), and (b) both prototype suits performed better than the interim SDES suit in the water spray tests (20°F air, 18 mph over 35°F water). Heat loss data under the three test conditions with the three suits indicated that the watertight slide fastener on the interim SDES suit and on the A prototype did not provide any significantly measurable added protection. Accordingly 20 B prototype suits with the brass slide fastener were manufactured for additional studies in 1975-76. These suits were classified as Mod I SDES suits.

A field evaluation was conducted aboard four Navy submarines and at a Coast Guard station, under sub-freezing, stormy, windy conditions from October 1975 to March 1976. Each activity was provided with Mod I SDES suits and Interim SDES suits. The major differences between the two suits were the type of slide fastener used, watertight for the Interim SDES vs. brass for the Mod I SDES, and the amount of insulation. The Mod I SDES was found by the test subjects to provide better wet/cold weather protection than the Interim SDES. The watertight slide fastener of the Interim SDES was reported as not providing any increased protection. The dry cold protection provided by both SDES's was reported as being adequate by the test subjects. Heat stress was reported as not being excessive in either type of suit when worn under relatively warm conditions.

Buoyancy studies were also conducted in 1975 by NCTRF to determine the inherent buoyancy and water pickup of the Mod I SDES and the Interim SDES. Results showed that the Mod I SDES had an increase of 9 pounds over the Interim SDES when tested statically and an increase of 20 pounds when tested with a live test subject in the NCTRF pool. Both SDES suits collected about the same amount of water when the test subject wore the suits in the water. Inasmuch as the static test was conducted with the suits wrapped tightly around a steel plate to eliminate trapped air before they were submerged, NCTRF determined that the correct increase in inherent buoyancy for the Mod I SDES was 9 pounds.



Figure 1. The Navy Submarine Deck Exposure Suit.

This report will cover the features of the new Mod I SDES and Interim SDES, the physiological, buoyancy and field evaluation studies, the test procedures used to establish the protective parameters of the two SDES, and the test results with conclusions and recommendations.

#### SUIT DESCRIPTIONS

The A, B (Mod I), and the Interim SDES are of a one-piece coverall-type construction with attached hood (see Figure 1). Each has a front-opening slide fastener running from the crotch to the neck to facilitate donning and doffing. Velcro closures secure the ankle sections of the legs and wrist sections of the arms around the cold-weather boots and gloves recommended for wear with the suit. The hood for each suit is secured with a tie cord under the chin. For each, a neoprene-coated nylon material was used for the outer fabric and nylon taffeta for the inner lining. Each utilized a closed-cell PVC-foam interlining for insulation and inherent buoyancy.

The major differences in the suits are the type of slide fastener and amount of insulation. The Interim suit and the A suit were equipped with a waterproof slide-fastener closure and had an insulation thickness of 1/8" in the legs, arms, and hood, and 1/4" in the torso area. The B (Mod I) suit had a regular brass slide fastener closure and an insulation thickness of 1/4" in the legs, arms, and hood, and 3/8" in the torso area.

The principal changes made to the A and B (Mod I) suits with regard to the Interim suit were for the purposes of improving cold-weather protection and inherent buoyancy by adding more insulation. Costs were reduced by replacing the waterproof slide fastener with a more conventional brass type for the B (Mod I) suit.

#### PHYSIOLOGICAL TESTING

Three studies, designed by NCTRF physiologists to compare the protective capabilities of the three SDES, were:

First study (Immersion Test),  
Second study (Spray Test), and a  
Third study (Dry/Cold Exposure Tests).

The following cold-weather clothing was worn with SDES suits during the studies:

Navy waffle knit underwear,  
Navy utility shirts and trousers,  
Cold-weather cushion sole socks,  
Navy cold-weather boots, and  
Navy cold-weather mittens.

## Test Procedure

First study (Immersion). The test subjects climbed down a ladder until immersed to their chins in 35°F (1.67°C) water, then they floated in a supine position except for arm and leg movements to prevent development of an orthostatic hypotension.

Second study (Spray). The test subjects were seated on a moveable platform, which was (1) raised above spray, (2) lowered through spray until water was about waist deep (spray beat down on head) and then, (3) raised through spray again. This cycle took about 1 minute and was repeated each 3 to 5 minutes. The water temperature was 35°F (1.67°C), the air temperature 20°F (-6.67°C), and the wind speed 18 mph.

Third study (Dry Cold). The test subjects stood in the main stream of an 18 mph wind created by fans. The ambient air temperature was 20°F (-6.67°C). A minimum amount of movement, every 10 minutes to prevent development of orthostatic hypotension, was required.

The description of the physical characteristics of test subjects and the complete description of pre-test procedure are included in Appendix A.

## Test Results

The test results from the three studies are tabulated in Tables I and II.

Table I presents the means  $\pm$  the standard error of the means of changes in parameters monitored or calculated from the three studies. The numbers in parentheses indicate the number of tests from which the means were derived. "p" and "t" values are not included because, with the exception of one instance, the calf area during the immersion test, all "p" values were greater than 0.2, and are not considered significant. The values represented are changes in measured data reduced to rate of change per hour for comparison purposes.

## Discussion of Results

Table I shows that the amount of time the test subjects tolerated exposure under the conditions of the dry-cold study was essentially the same.

The Interim SDES had the shortest exposure time during the spray and immersion study. Suit B had the longest exposure time during immersion study while Suit A had the longest exposure time during the spray study. It is noted that both A and B suits with the increased insulation did very well time-wise whereas the Interim suit with less insulation did not fare as well, except in the dry-cold study in which, it appears from the test data, increased insulation is not meaningful when the suits are exposed only to wind speeds of 18 mph and ambient temperatures of 20°F. Lower ambient temperatures could make a difference.

Table I. Physiological Data for Submarine Deck Exposure Suits Evaluated Under the Various Environmental Conditions

Parameter	DRY COLD			SPRAY		
	A	B	Interim	A	B	Interim
Rectal Temp. (°C/Hr.)	0.1±0.07 (9)	0.00±0.05 (8)	0.00±0.05 (11)	0.27±0.05 (5)	0.21±0.05 (5)	0.33±0.05 (6)
Mean Body Temp. (°C/Hr.)	0.51±0.06 (9)	0.54±0.04 (8)	0.46±0.06 (11)	1.18±0.08 (6)	1.08±0.08 (6)	1.18±0.05 (5)
WMST (°C/Hr.)	2.81±0.09 (10)	2.49±0.12 (9)	2.57±0.13 (7)	4.52±0.19 (5)	5.08±0.22 (6)	4.83±0.40 (5)
Calf Skin (°C/Hr.)	1.26±0.16 (10)	1.55±0.15 (7)	1.85±0.28 (8)	3.49±0.20 (4)	3.24±0.19 (6)	3.90±0.17 (5)
Lateral Thigh Skin (°C/Hr.)	1.23±0.13 (6)	1.08±0.19 (11)	1.50±0.17 (11)	2.15±0.22 (5)	4.09±0.37 (5)	2.47±0.37 (5)
Medial Thigh Skin (°C/Hr.)	0.71±0.15 (9)	1.07±0.21 (11)	0.84±0.14 (8)	4.46±0.33 (6)	4.25±0.43 (5)	4.66±0.38 (5)
Back Skin (°C/Hr.)	0.75±0.56 (9)	0.94±0.08 (8)	1.11±0.19 (8)	1.84±0.44 (5)	2.49±0.39 (6)	2.82±0.46 (5)
Chest Skin (°C/Hr.)	1.01±0.20 (8)	0.63±0.09 (8)	1.08±0.19 (7)	1.51±0.39 (5)	1.18±0.26 (6)	0.20±0.20 (5)
Upper Arm Skin (°C/Hr.)	1.88±0.05 (11)	1.80±0.20 (7)	1.69±0.25 (9)	2.54±0.18 (5)	2.19±0.07 (4)	2.76±0.17 (5)
Lower Arm Skin (°C/Hr.)	3.25±0.20 (10)	3.36±0.20 (10)	3.15±0.24 (10)	8.06±1.07 (6)	9.00±0.60 (4)	9.78±0.54 (5)
Heat Content (kcal/Hr/m <sup>2</sup> )	15.64±1.75 (10)	15.81±1.41 (9)	14.24±2.13 (11)	33.35±2.25 (5)	32.46±1.81 (6)	36.10±1.39 (5)
Times (Min.)	119±0.77 (13)	120±0 (12)	119±1 (12)	110±6 (5)	94±2 (5)	87±3 (3)

Table I. Physiological Data for Submarine Deck Exposure Suits Evaluated Under the Various Environmental Conditions (cont'd)

Parameter	IMMERSION		
	A	B	Interim
Rectal Temp. (°C/Hr.)	2.07±0.19 (9)	0.62±0.46 (10)	1.38±0.40 (10)
Mean Body Temp. (°C/Hr.)	4.89±0.32 (9)	4.24±0.40 (10)	4.19±0.39 (10)
WMST (°C/Hr.)	16.79±0.90 (11)	16.94±0.79 (11)	18.13±1.65 (10)
Calf Skin (°C/Hr.)	21.77±2.27 (11)	19.89±1.43 (13)	41.00±0.10 (10)
Lateral Thigh Skin (°C/Hr.)	22.93±1.09 (13)	23.90±0.75 (11)	25.47±1.86 (9)
Medial Thigh Skin (°C/Hr.)	22.03±1.51 (13)	20.60±0.71 (10)	22.92±2.24 (9)
Back Skin (°C/Hr.)	12.40±1.20 (11)	10.46±0.95 (8)	14.40±1.79 (8)
Chest Skin (°C/Hr.)	13.15±1.51 (11)	13.78±1.06 (10)	16.79±2.42 (9)
Upper Arm Skin (°C/Hr.)	20.89±1.67 (11)	17.86±0.94 (8)	17.65±1.71 (11)
Lower Arm Skin (°C/Hr.)	22.59±1.95 (11)	20.85±0.82 (8)	19.02±1.98 (10)
Heat Content (kcal/Hr./m <sup>2</sup> )	143.63±11.38 (10)	120.91±13.22 (9)	115.57±10.46 (10)
Times (Min.)	42±1 (12)	45±0 (8)	39±1 (6)

Table II is a presentation of a method of ranking the performance of each suit for some of the monitored parameters. It should be emphasized that there is no statistical validity to this method of presentation of study results which merely offers a method of scaling performance when monitored parameters show no demonstrably significant differences. Rating values were assigned based on the mean performance values shown in Table II. A value of 1 was assigned for best mean value; 3 for worst performance. If the change for two suits was the same, the next lower ranking was assigned to both. Values of the skin site probes were totaled for each test situation for each suit. The one with the lowest score was then judged to render the best performance in protecting the wearer.

When ranked in this way suit B ranked higher than the other suits in both wet studies and was at least equal to the others in the dry-cold study, based upon both rectal and total skin site rankings. There was no definitive difference in the immersion test between suits A and the Interim. Skin site rankings indicated A was better than the Interim in both wet tests, but rectal data indicated the Interim to be better than A in immersion studies. For the dry-cold studies A, B and the Interim were equal based upon skin site rankings but rectal data indicated B and the Interim were best.

The physiologists and test personnel agreed that the best of these three suits is the type B suit. Heat loss data under the three study conditions with the three suits did not indicate that the two suits, type A and the Interim, which had the water tight zipper provided any significantly measurable added protection. Further use of this type of zipper does not appear warranted.

#### BUOYANCY TESTS (IN-HOUSE)

There were two suits tested--the Mod I SDES and the Interim SDES. One suit was taken from a 20-suit production lot made from prototype "B" patterns. This suit was classified as a Mod I SDES; the other suit was the Interim SDES.

#### Static Buoyancy Study

The static buoyancy study was conducted in the NCTRF Marine Chamber with the suits wrapped tightly around a heavy steel plate used to produce negative buoyancy. A spring scale was used to record all test results. The procedure was to establish the weight of the ballast in water and the weight of the test suit with the ballast in water. All study results were recorded with the test suit and steel plate submerged completely in water.

#### Suit Buoyancy Study Procedure

The suit buoyancy study of the two suits was conducted in the NCTRF Marine pool with the test subject wearing the same cold weather under-clothing components that were worn during the physiological tests. The test procedure was for the test subject to enter the pool via a ladder. The test subject

Table II. Ranking Information and Number of Tests for Rectal and Skin Probe Temperature Data for the Submarine Deck Exposure Suits Evaluated Under the Various Environmental Test Conditions

Parameter	Ranking												No. of Tests					
	Environmental Condition						Environmental Condition						Environmental Condition					
	Dry Cold			Spray			Immersion			Dry Cold			Spray			Immersion		
	A	B	Int.	A	B	Int.	A	B	Int.	A	B	Int.	A	B	Int.	A	B	Int.
Rectal	3	2	2	2	1	3	3	1	2	9	8	11	5	5	6	9	10	10
Calf	1	2	3	2	1	3	3	1	2	10	7	8	4	6	5	11	13	9
Lateral Thigh	2	1	3	1	3	2	1	2	3	6	11	11	5	5	5	13	11	9
Medial Thigh	1	3	2	2	1	3	2	1	3	9	11	8	6	5	5	13	10	9
Back	3	2	1	1	2	3	2	1	3	9	8	8	5	6	5	11	9	8
Chest	2	1	3	3	2	1	1	2	3	8	8	7	5	6	5	11	10	9
Upper Arm	3	2	1	2	1	3	3	2	1	11	7	9	5	4	5	11	8	11
Lower Arm	2	3	1	1	2	3	3	2	1	10	10	10	6	4	5	11	8	10
Total Skin Sites	14	14	14	12	12	18	15	11	16									

Ranking Code: 1-Best; 2-Middle; 3-Worst

Note 1: When ties occurred between suits, the suits received the same ranking and were given the next lowest ranking (i.e., if A and B were equal and higher ranked than the Interim, A and B were given a 2 ranking and the Interim a 3 ranking).

Note 2: Table represents a presentation of performance rating where the three suits are compared to each other on the basis of information from Table I. The better the comparative performance, the lower the number, Total points scored, then, form a basis for forming an opinion of performance of a suit under all three test conditions. The second part of this table presents the number of tests performed and also repeats the information in parenthesis from Table I.

climbed into a specially constructed harness which was attached to a spring balance that was attached to a chain hoist. Two assistants in Navy wet suits added ballast weights to the harness until the test subject and the suit were negatively buoyant. The chain hoist lowered the test subject and suit until both were completely submerged for 60 seconds. The weight of the ballast was established for each reading. Negative buoyancy of test subject and suit was established.

#### Water Gain Test Procedure

The water gain test determined the amount of water which enters each suit when worn by a test subject outfitted with cold weather components worn in the above physiological studies.

The test subject climbed out of the pool and stood in a flat pan in which the water drain-off was collected.

Calculations were made and recorded in Table III, which is a tabulation of test results using above test procedures to determine the static buoyancy, the effective buoyancy of each suit when worn, and the water gain.

Table III - Buoyancy and Water Gain Results

##### A. Static Buoyancy

Weight of plate in water	37 lbs.
Weight of plate & Mod I SDES	<u>-9 lbs.</u>
Buoyancy of Mod I SDES	28 lbs.

.....

Weight of plate in water	37 lbs.
Weight of plate and Interim SDES in water	<u>-18 lbs.</u>
Buoyancy of Interim SDES	19 lbs.

.....

##### B. Suit Buoyancy (with test subject)

Weight of ballast in water	58 lbs.
Weight of ballast and Mod I SDES in water	<u>-14 lbs.</u>
Effective buoyancy of Mod I SDES & test subject	44 lbs.

.....

Weight of ballast in water	58 lbs.
Weight of ballast and Interim SDES in water	<u>-34 lbs.</u>
Effective buoyancy of Interim SDES and test subject	24 lbs.

.....

C. Water Gain (with test subject)

Weight of test subject and Mod I SDES after excess water drained	194.9 lbs.
Dry weight of test subject and Mod I SDES with boots and mittens	-190.9 lbs.
Weight of water retained in Mod I SDES	<u>4.9 lbs.</u>

.....

Weight of test subject and Interim suit with boots and mittens after excess water drained off	194.7 lbs.
Dry weight of test subject and Interim SDES with boots and mittens	-189.0 lbs.
Weight of water retained in Interim SDES, boots and mittens	<u>5.7 lbs.</u>

.....

Weight of pan and water drained from Mod I SDES	20.4 lbs.
Dry weight of Pan	-2.2 lbs.
Weight of water drained from Mod I SDES	<u>18.2 lbs.</u>

.....

Weight of pan and water drained from Interim SDES	22.1 lbs.
Dry weight of pan	-2.2 lbs.
Weight of water drained from Interim SDES	<u>19.9 lbs.</u>

Discussion of Results

The static buoyancy test showed that the Mod I SDES with 28 lbs. of inherent buoyancy had 9 more lbs. than the Interim SDES with 19 lbs.

The suit buoyancy test with a test subject wearing each suit with boots and mittens indicated that the Mod I SDES had 44 lbs. of effective buoyancy while the Interim SDES had 24 lbs.--a difference of 20 lbs. It should be noted that this type of buoyancy is not stable, because much of it is the result of trapped air bubbles. These bubbles escape as the water penetrates the suit through the leg and the sleeve bottoms and through the neck opening. Stabilization of the effective buoyancy could not be accomplished because of the very limited time (60 seconds) that the test subject could hold his breath while completely submerged.

The water gain test clearly demonstrated the tremendous amount of water that penetrated the neck, sleeve and leg openings of the SDES. The Mod I SDES collected a total of 23.1 lbs. and the Interim SDES collected a total of 25.6 lbs. while in the water. Even after all possible water had been drained from the SDES, boots and mittens, the Mod I SDES still retained 4.9 lbs. and the Interim SDES 5.7 lbs. of water(which could not be drained from the SDES suits). This indicates that the waterproof slide fastener of the Interim SDES could not prevent water penetration during immersion conditions.

## FIELD EVALUATION OF SUBMARINE DECK EXPOSURE SUIT

The field evaluation of the new Mod I SDES was conducted aboard four Navy submarines and at a Coast Guard (CG) station to establish if design changes in the Mod I SDES as related to the Interim SDES currently in use were significant.

The evaluation was conducted between October 1975 and March 1976 aboard the USS STURGEON (SSN 637), USS PARGO (SSN 650), USS GATO (SSN 615), USS DACE (SSN 607), and at the Point Allerton CG Station, Hull, MA.

### Evaluation Procedures

Each boat taking part in the field evaluation study was issued three medium-sized Mod I SDES. Each had already been issued 12 Interim SDES covering a full size range from small to extra large. The CG activity was given two medium-sized Mod I SDES and two Interim SDES (1 large and 1 extra large). All activities were provided with enough questionnaires so that each person who wore the Mod I or Interim SDES had an opportunity to offer his opinion of the suits.

At the conclusion of the 90-day evaluation, each subject was asked to fill out a questionnaire giving his best recollection of the performance of each suit type under the conditions which he experienced. The suits were to be worn under normal working duties. Except for the CG activity, no special test criteria were set up to evaluate a specific suit characteristic. At the CG activity, a man-overboard situation was simulated to estimate the degree of buoyancy and thermal protection provided by the SDES in cold water.

The questionnaires (Appendix B) were designed to solicit the following information:

- a. Anthropological characteristics of volunteers.
- b. Types of duties performed
- c. Amount of time each type of SDES was worn.

### Anthropological Characteristics of Volunteers and Suit Sizes Worn

Table IV provides anthropological characteristics and data on the suit sizes worn for all volunteers who completed a questionnaire form. For those who wore the Mod I and Interim SDES approximately 30% were too big for the size suit they wore. Most test subjects could wear both types of SDES.

Table IV. Anthropological Characteristics of Volunteers and Suit Sizes Worn

Activity	Volunteer			Height (inches)	Weight (lbs.)	Size Class	SDES Size Worn	
	ID	Rank*	Age (years)				Mod I	Interim
USS STURGEON SSN 637	M.M.	E	19	70	139	Med.	Med.	
	M.G.	E	23	72	220	Lg.	Med.	Lg.
	J.N.	E	22	72	190	Lg.	Med.	Lg.
	R.G.	E.	21	69	215	Lg.	Med.	
	C.A.	E	23	70	160	Med.	Med.	
	R.B.	E	21	68	200	Lg.	Med.	Med.
	J.E.	E	23	69	170	Med.	Med.	Med.
	R.M.	E	19	71	200	Lg.	Med.	Med.
	R.W.	O	32	69	180	Med.	Med.	Med.
	K.E.	E	20	68	160	Med.	Med.	Med.
	A.H.	E	23	66	160	Med.	Med.	Med.
	R.T.	E	20	72	180	Lg.	Med.	Med.
	C.S.	O	25	73	170	Lg.	Med.	Med.
	J.R.	O	39	69	175	Med.	Med.	Med.
	J.A.	O	24	72	185	Lg.	Med.	Med.
	G.V.	O	25	73	185	Lg.	Med.	Med.
	J.M.	O	25	72	165	Med.	Med.	Med.
USS PARGO SSN 650	W.S.	O	37	71	165	Med.	Med.	Med.
	E.B.	O	27	72	205	Lg.		XLg.
	G.G.	O	24	73	185	Lg.	Med.	Med.
	J.A.	O	25	69	150	Med.	Med.	Unk.
USS GATO SSN 615	G.M.	E	23	67	170	Med.	Med.	Med.
	R.D.	E	32	72	145	Med.	Med.	Med.
	C.B.	O	31	66	160	Med.	Med.	Med.
	G.S.	O	24	68	150	Med.	Med.	
	D.T.	O	22	69	155	Med.	Med.	Lg.
USS DACE SSN 607	R.P.	O	26	71	175	Med.	Med.	Lg.
	P.R.	O	34	71	190	Lg.	Med.	Med.
	V.S.	O	31	74	195	Lg.		Lg.
	J.M.	E	19	70	189	Lg.	Med.	Unk.
	S.C.	E	22	69	155	Med.	Med.	Med.
	M.S.	E	19	71	155	Med.	Med.	Med.
	T.K.	E	19	68	155	Med.	Med.	Med.
COAST GUARD	J.W.	E	25	70	170	Med.	Med.	
	V.F.	E	23	71	170	Med.	Med.	
	C.B.	E	28	74	215	Lg.		XLg.
	T.S.	E	20	66	160	Med.	Med.	
	L.P.	E	19	72	155	Med.	Med.	
	W.N.	E	21	72	140	Med.	Med.	
	L.S.	E	21	65	140	Sm.	Med.	

\*E - Enlisted

O - Officer

### Duty Assignments

Tables V and VI list the types of functions performed at the participating activities while the suits were worn (Table V). The principal duties performed by enlisted submarine personnel were topside watch in port and lookout at sea (Table V). The main duty of officers was acting as Officer of the Deck. Personnel search and rescue missions were the most noted assignments of the CG personnel (Table VI).

Table V. Duty Assignments for Submarine Personnel

Activity	Subject		Type of Duty					OOD	CO
	ID	Size	Lookout	Topside	Watch	Deck	Duty		
USS STURGEON SSN 637	M.M.	Med.	x						
	M.G.	Lg.	x	x					
	J.N.	Lg.	x	x					
	R.G.	Lg.		x					
	C.A.	Med.	x						
	R.B.	Lg.		x					
	J.E.	Med.		x			x		
	R.M.	Lg.						x	
	R.W.	Med.	x						
	K.E.	Med.	x	x					
	A.H.	Med.	x	x					
	R.T.	Lg.	x						
	C.S.	Lg.	x	x				x	
	J.R.	Med.							x
	J.A.	Lg.	x	x				x	
	G.V.	Lg.	x	x				x	
	J.M.	Med.						x	
USS PARGO SSN 650	W.S.	Med.						x	
	E.B.	Lg.						x	
	G.G.	Lg.						x	
	J.A.	Med.						x	
USS GATO SSN 615	G.M.	Med.		x			x		
	R.D.	Med.		x			x		
	C.B.	Med.						x	
	G.C.	Med.					x		
	D.T.	Med.						x	
USS DACE SSN 607	R.P.	Med.		x					
	P.R.	Lg.						x	
	V.S.	Lg.						x	
	J.M.	Lg.	x	x					
	S.C.	Med.	x	x					
	M.S.	Med.	x	x					
	T.K.	Med.		x					

Table VI. Duty Assignments for Coast Guard Personnel

Activity	Subject		Search & Rescue	Type of Duty			
	ID	Size		Coxswain	Fire- Fighting	In Water Salvage	Deck Work
COAST GUARD	J.W.	Med.		x			
	V.F.	Med.	x		x		
	C.B.	Lg.	x			x	
	T.S.	Med.	x				x
	L.P.	Med.	x				
	W.N.	Med.	x		x		
	L.S.	Sm.	x				

Wear Data and Suit Preference

Wear Data. Table VII lists the hours each suit was worn by the volunteers. The Mod I SDES was worn a total of 1,478 hours and the Interim SDES 1,120 hours. USS DACE SSN 607 personnel accounted for 50% of the Mod I SDES total and 60% of the Interim SDES total. The USS STURGEON SSN 637 personnel accounted for 30% of the Mod I SDES wear and 22% of the Interim SDES wear.

Suit Preference. Those who wore both suits (27) preferred the following:

<u>Period</u>	<u>Mod I SDES</u>	<u>Interim SDES</u>	<u>Either</u>	<u>Neither</u>
Initial(%)	40	12	48	
Final (%)	73	8	15	4

As can be seen the final preference by a substantial majority was for the Mod I SDES as opposed to the standard (73 versus 8%). Only 15% had no preference. A very low percentage (4%) disliked both suit types. Initial preference data were not significant, because nearly half the participants (48%) did not make a specific suit choice.

Table VII. Wear Data and Suit Preference

Activity	Volunteer		Type Suit (hrs.)		SDES Initial	Preference	
	ID	Size	EXP.	STD.		Initial	Final
USS STURGEON SSN 637	M.M.	Med.	6		Only Wore Mod I		
	M.G.	Lg.	18	12			Mod I
	J.N.	Lg.	48	48	Either		Mod I
	R.G.	Lg.	13		Only Wore Mod I		
	C.A.	Med.	24		Only Wore Mod I		
	R.B.	Lg.	12	8	Mod I		Mod I
	J.E.	Med.	8	8	Interim		Interim
	R.M.	Lg.	16	16	Either		Either
	R.W.	Med.	42	12	Mod I		Mod I
	K.E.	Med.	187	20	Either		Mod I
	A.H.	Med.	32	76	Either		Interim
	R.T.	Lg.	8	8	Either		Either

Table VII. Wear Data and Suit Preference (cont'd)

Activity	Volunteer		Type Suit (hrs.)		SDES Preference	
	ID	Size	EXP.	STD.	Initial	Final
USS STURGEON SSN 637	C.S.	Lg.	6	12	Either	Mod I
	J.R.	Med.	8		Only Wore	Mod I
	J.A.	Lg.	6	6	Interim	Mod I
	G.V.	Lg.	3	12	Either	Mod I
	J.M.	Med.	5	10	Mod I	Mod I
USS PARGO SSN 650	W.S.	Med.	10	6	Either	Either
	E.B.	Lg.		19	Only Wore	Interim
	G.G.	Lg.	9	26	Either	Mod I
	J.A.	Med.	14	10	Either	Either
USS GATO SSN 615	G.M.	Med.	90	8	Mod I	Mod I
	R.D.	Med.	4	8	Mod I	Mod I
	C.B.	Med.	5	15	Either	Mod I
	G.S.	Med.	8		Only Wore	Mod I
	D.T.	Med.	32	12	Mod I	Mod I
USS DACE SSN 607	R.P.	Med.	6	16	Interim	Neither
	P.R.	Lg.	40	20	Mod I	Mod I
	V.S.	Lg.		100	Only Wore	Std.
	J.M.	Lg.	40	20	Mod I	Mod I
	S.C.	Med.	50	30	Mod I	Mod I
	M.S.	Med.	600	500	Mod I	Mod I
	T.K.	Med.	6	12	Either	Mod I
COAST GUARD	J.W.	Med.	40		Only Wore	Mod I
	V.F.	Med.	25		Only Wore	Mod I
	C.B.	Lg.		70	Only Wore	Interim
	T.S.	Med.	20		Only Wore	Mod I
	L.P.	Med.	18		Only Wore	Mod I
	W.N.	Med.	8		Only Wore	Mod I
	L.S.	Sm.	11		Only Wore	Mod I
Total			1478	1120		

Cold ExposureExperimental SDES.

Table VIII contains the cold exposure data for the Mod I SDES. There were 37 respondents to the cold exposure questions. Comments were made covering a temperature range of -40 to 50°F. For the entire temperature range 62% indicated they were not cold. Of all responses 81% fell within a temperature range of 0 to 35°F. Of these responses 60% indicated they were not cold.

It would normally be expected that exposure times at the various temperature levels had some influence on volunteer comfort but, because most responses indicated significant exposure durations (80% were 3 hours or more), no apparent distortion is caused by just pooling all data without regard to exposure time. For instance, if only 4-hour exposures are considered for the temperature range from 0 to 35°F (10 responses), 60% of these volunteers indicated they were not cold. This result is identical to that obtained when all responses (30) for this temperature range are considered.

Table VIII. Cold Exposure - Mod I SDES

Subject I.D. Size	Temp. (°F)	Exposure Conditions		Comfort				Body Area Affected**										Remarks																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
		Time (Hrs.)	Other*	W	R	S	GW	WS	He	Sh	Ba	Ch	Le	Ar	Hd	Ft	Th																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
J.W. Med.	-40	2		x	x		x																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

\* W-Wind; R-Rain; S-Snow; GW-Green Water; WS-Water Spray

\*\* He-Head; Sh-Shoulder; Ba-Back; Ch-Chest; Th-Thigh; Le-Leg; Ar-Arm; Hd-Head; Ft-Feet.

Table VIII. Cold Exposure ~ Mcd I SDES (cont'd.)

Subject			Exposure Conditions				Comfort		Body Area Affected**							Remarks
I.D.	Size	Temp. (°F)	Time (Hrs.)	Other*				He	Sh	Ba	Ch	Le	Ar	Hd	Ft	
				W	R	S	GW	WS								
G.S.	Med.	15	6	x			x		Not Cold							
R.B.	Lg.	18	4						Not Cold							
R.T.	Lg.	20	4	x	x			x	Not Cold							
J.E.	Med.	20	4	x	x	x			Cold			x				
C.	Med.	25	3	x	x	x	x		Not Cold							
W.S.	Med.	25	5	x					Not Cold							
J.A.	Lg.	25	6	x	x				Not Cold							
C.S.	Lg.	25	6	x	x				Cold			x				Neck Cold
G.M.	Med.	30		x	x	x	x		Not Cold							
R.D.	Med.	30	3	x					Not Cold							
J.M.	Med.	30	3	x	x			x	Cold					x	x	Face Cold
R.G.	Lg.	30	3	x	x	x			Cold	x						
J.M.	Lg.	34	4	x	x	x	x		Not Cold							
M.S.	Med.	35	6	x	x	x	x		Cold							
G.V.	Lg.	40	3	x	x	x			Cold	x		x	x			
T.K.	Med.	40	6	x					Not Cold							
P.R.	Lg.	40	6				x		Not Cold							
R.P.	Med.	50	6	x			x		Cold				x		x	

\* W-Wind; R-Rain; S-Snow; GW-Green Water; WS-Water Spray

**\*\*** He-Head; Sh-Shoulder; Ba-Back; Ch-Chest; Th-Thigh; Le-Leg; Ar-Arm;  
Hd-Hand; Ft-Feet.

For those personnel who felt cold (38%), the presence of the elements of wind and rain were indicated in almost 80% of the cases. For those who were not cold these elements were present in 55 to 70% of the cases. The other elements (snow, green water, and water spray) were indicated in less than 35% of the responses whether cold or not cold.

The body area mentioned most by personnel who felt cold was the head (57%). The legs were second in frequency. Thirty-six percent indicated their legs were cold with the back and shoulders and arms mentioned in decreasing order of frequency as 28 and 21% of the time, respectively. All other areas were mentioned 7% of the time or less.

Interim SDES. Table IX contains the cold exposure data for the Interim SDES. There were 29 respondents to the cold exposure questions. Comments covered a temperature range of -25 to 50°F. For the entire range only 31% indicated they were not cold. For the temperature range from 0 to 35°F, which included 72% of the responses, only 20% were not cold.

If only 4-hour exposure times are considered over the temperature range of 0 to 35°F (7 responses), only 14% (1 of 7) were not cold, which is close to the result obtained when all data were pooled without regard to exposure time. As noted earlier, this good correspondence occurred because exposures were for substantial time periods (3 hours or more) in the large majority of the cases. For the cold responses received for this suit over the 0 to 35°F temperature range, 86% were for 3 hours or more.

For those personnel who felt cold (69%), the presence of the elements of wind or rain was indicated in 75% of the cases. For those who were not cold these elements were present in 66% of the cases. The elements of snow and green water were present in 45 to 50% of the cases for those who were cold, whereas these elements were indicated in only 22% or less of the cases for those who were not cold. Water spray for people who were cold or not cold was mentioned in only about 20% of the cases.

As occurred for the experimental suit people who were cold mentioned the head most often (60% of the cases); the legs and arms in at least 50% of the cases; shoulders, back, and chest in 35% of the cases; and all other areas 20% or less.

#### Topside Protection

Mod I SDES. Of 35 responses, 24 (68%) indicated the suit provided adequate topside protection. For the 32% who thought the suit did not provide adequate protection, they mentioned most often rain (63%), green water (54%), and water spray (36%) as those elements against which protection was not adequate. Wind and snow were only mentioned in less than 18% of these cases. The body areas mentioned as not being adequately protected from these elements were in order of frequency: the head (45%); neck, chest and legs (27%); arms (18%); and shoulders, back, and thighs (9%).

Interim SDES. Of 27 responses, 14 (52%) indicated the suit provided adequate topside protection. For the 48% who did not think protection was adequate, the elements mentioned most against which protection was not considered adequate were rain (69%), green water (61%), and water spray (54%). Snow was

Table IX. Cold Exposure-Interim SDES

Subject		Exposure Conditions				Comfort		Body Area Affected**										Remarks
I.D.	Size	Temp. (°F)	Time (Hrs.)	Other*					He	Sh	Ba	Ch	Th	Le	Ar	Hd	Ft	
				W	R	S	GW	WS										
R.D.	Med.	-25	8	x					Cold	x	x	x	x	x	x	x	x	
E.B.	Lg.	-5	4	x		x			Cold							x	x	
C.B.	Lg.	-5	7	x	x	x	x		Cold	x				x	x			
J.N.	Lg.	0	2	x	x		x		Cold		x							
A.H.	Med.	0	4	x				x	Not Cold									
K.E.	Med.	0	4	x	x	x	x		Cold	x	x		x					
J.A.	Med.	5	10	x	x				Not Cold									
G.G.	Lg.	7	3	x	x	x			Cold	x								Neck Cold
V.	Lg.	10	2						Not Cold									
C.	Med.	10	3		x	x	x		Cold	x	x	x	x	x	x	x	x	
R.M.	Lg.	10	4	x		x			Cold	x				x				
M.G.	Lg.	10	6	x	x		x		Cold	x					x			
S.C.	Med.	15	4	x	x	x	x		Cold	x				x	x			
W.S.	Med.	15	5	x	x				Not Cold									
R.T.	Lg.	20	4	x	x			x	Not Cold									

\* W-Wind; R-Rain; S-Snow; GW-Green Water; WS-Water Spray

\*\* He-Head; Sh-Shoulder; Ba-Back; Ch-Chest; Th-Thigh; Le-Leg; Ar-Arm; Hd-Head; Ft-Ft.

Table IX. Cold Exposure-Interim SDES (cont'd.)

Subject		Exposure Conditions				Comfort		Body Area Affected**										Remarks
I.D.	Size	Temp. (°F)	Time (Hrs.)	Other*				He	Sh	Ba	Ch	Th	Le	Ar	Hd	Ft		
				W	R	S	GW	WS										
D.T.	Med.	20	4	x	x			x	Cold	x	x	x	x	x	x	x	Neck Cold	
J.E.	Med.	20	4	x	x	x			Cold	x								
R.B.	Lg.	20	4						Cold				x					
J.A.	Lg.	25	6	x	x				Not Cold									
R.W.	Med.	25	6	x	x	x		x	Cold	x				x				
G.M.	Med.	30		x	x	x	x		Cold	x								
J.M.	Lg.	34	10	x	x	x	x		Not Cold									
M.S.	Med.	35	6	x					Cold	x	x			x			Neck Cold	
C.S.	Lg.	35	6						Cold									
P.R.	Lg.	40	2				x		Not Cold									
J.M.	Med.	40	6	x	x			x	Cold						x	x	Face Cold	
G.V.	Lg.	40	12	x	x				Cold	x								
T.K.	Med.	45	4	x					Not Cold									
R.P.	Med.	50	6	x	x		x		Cold					x		x		

\* W-Wind; R-Rain; S-Snow; CW-Green Water; WS-Water Spray

\*\* He-Head; Sh-Shoulder; Ba-Back; Ch-Chest; Th-Thigh; Le-Leg; Ar-Arm; Hd-Head; Ft-Feet.

only mentioned in 31% of these cases and wind was not mentioned at all. Those body areas perceived to be inadequately protected, in order of response frequency, were: head (46%); arms, legs, and chest (38%); back (31%); neck and shoulders (23%); and thighs, hands, and feet (15%).

#### Warm Temperatures

Mod I SDES. Table X gives the warm temperature results for this suit. For the entire temperature range (20 to 75°F), 62% (37 responses) felt hot. For the range 40 to 75°F, 68% (28 responses) were hot. For exposures of 4 hours or more from 40 to 75°F, 62% (13 responses) felt hot. As occurred for the cold response data, results were similar whether exposure times were considered or not. For the 23 respondents who were hot the body area most noted was the chest (87% of the cases). The other areas in order of frequency of response were back (70%), legs and arms (56%), shoulders (43%), and thighs (39%).

Standard SDES. Table XI gives the warm temperature data for this suit. For the entire temperature range (20 to 75°F) for which responses were received, 61% (28 responses) felt hot. Over the range 40 to 75°F (22 responses), 72% felt hot. For 4-hour exposures over the 40 to 75°F temperature range (13 responses), 69% felt hot. As shown previously, the results were almost equivalent to pooled data which disregarded exposure time information.

For those 17 subjects who felt hot the body area indicated most was the chest (88%). The other areas mentioned in order of frequency of response were back (65%), arms (58%), legs (53%), thighs (47%), and shoulders (41%).

#### Immersion Performance

Only one participant tested both suit types in water. Water temperature was 45°F and exposure time was 1.5 hours for both suits. No discomfort occurred in the chest, leg, and arm body areas but there were cold spots at the wrists and ankles for both suits. The subject indicated that an inflatable collar should be provided to keep the head out of water if the person became unconscious after falling overboard.

#### Comments on Suit Characteristics

The following comments were obtained from both questionnaires and debriefing sessions.

Size. We received comments on suit sizes from 25 subjects but disregarded the statements of five participants who wore undersized suits. Of those persons whose comments were considered valid, 11 indicated that either the arms or the legs or both were too short, eight that the suit was small overall, and three that the torso should be longer.

Hood and Neck Area. Twenty-six people commented on the hood and neck area of the suits. Most of the comments (15) concerned inadequate sealing at the neck which allowed wind and water to penetrate the suit at this area. Several of the personnel wore towels around their necks to reduce the penetration. Other

Table X. Warm Temperature Results - Mod I SDES

Subject		Exposure Conditions			Body Area Affected*								
I.D.	Size	Temp. (°F)	Time (Hrs.)	Comfort	He	Sh	Ba	Ch	Th	Le	Ar	Hd	Ft
R.D.	Med.	20	1	Hot	x	x	x	x	x	x	x		
D.T.	Med.	30	1	Not Hot									
C.	Med.	30	1	Hot		x		x	x	x	x		
G.S.	Med.	30	2	Not Hot									
G.G.	Lg.	30	3	Not Hot									
C.A.	Med.	30	4	Hot			x	x					
W.S.	Med.	30	5	Hot				x					
M.G.	Lg.	32		Not Hot									
R.T.	Lg.	35	4	Not Hot									
R.B.	Lg.	40	2	Not Hot									
W.N.	Med.	40	2	Not Hot									
M.M.	Med.	40	2	Hot				x					
L.	Med.	40	3	Hot			x	x	x				
T.K.	Med.	40	6	Hot				x		x	x		
L.S.	Sm.	43	3	Not Hot									
J.A.	Med.	45	2.5	Hot		x	x	x	x	x	x		
A.H.	Med.	45	4	Not Hot									
J.E.	Med.	45	4	Hot	x		x	x					
J.N.	Lg.	45	4	Hot	x	x	x	x	x	x	x		
C.S.	Lg.	45	6	Hot						x	x		
V.S.	Med.	50	1	Hot		x	x	x	x	x	x		
R.G.	Lg.	50	2	Hot	x	x		x		x	x		
J.W.	Med.	50	2-3	Hot	x	x	x	x	x	x			
S.C.	Med.	50	4	Hot	x	x	x	x	x	x	x		
R.W.	Med.	50	6	Hot	x		x	x				x	
P.R.	Lg.	50	6	Hot		x	x			x			
T.S.	Med.	55	.75	Hot		x	x	x					
G.V.	Lg.	55	1	Hot			x	x				x	
M.S.	Med.	55	4	Not Hot									
R.P.	Med.	55	6	Hot		x	x			x			
J.R.	Med.	60	1	Not Hot									
J.M.	Med.	60	2	Not Hot									
G.M.	Med.	60	3	Not Hot									
R.M.	Lg.	60	4	Not Hot									
K.E.	Med.	60	4	Hot			x	x				x	
J.M.	Lg.	65	4	Hot			x	x	x	x			
J.A.	Lg.	75	.50	Hot				x				x	

\* He-Head; Sh-Shoulder; Ba-Back; Ch-Chest; Th-Thigh; Le-Leg; Ar-Arm;  
Hd-Head; Ft-Feet.

Table XI. Warm Temperature - Interim SDES

Subject		Exposure Conditions			Body Area Affected*								
I.D.	Size	Temp. (°F)	Time (Hrs.)	Comfort	He	Sh	Ba	Ch	Th	Le	Ar	Hd	Ft
D.T.	Med.	20	3	Not Hot									
C.	Med.	25	3	Not Hot									
W.S.	Med.	30	1	Not Hot									
C.S.	Lg.	30	6	Hot						x	x		
M.G.	Lg.	32		Not Hot									
R.T.	Lg.	35	4	Not Hot									
R.D.	Med.	40		Not Hot									
R.B.	Lg.	40	2	Not Hot									
A.H.	Med.	45	4	Not Hot									
J.E.	Med.	45	4	Hot	x		x	x					
J.N.	Lg.	45	4	Hot	x	x	x	x	x	x	x		
J.A.	Med.	45	8	Hot		x	x	x	x	x	x		
V.	Lg.	50	2	Hot				x	x				
T.K.	Med.	50	4	Not Hot									
S.C.	Med.	50	4	Hot	x	x	x	x	x	x	x		
G.M.	Med.	50	5	Hot		x		x	x	x			
R.W.	Med.	50	6	Hot	x		x	x				x	
C.B.	Lg.	52	2	Hot		x	x	x	x				
G.V.	Lg.	55	1	Hot			x	x				x	
P.R.	Lg.	55	2	Hot						x	x		
M.S.	Med.	55	4	Not Hot									
R.P.	Med.	55	6	Hot		x		x		x			
R.M.	Lg.	60	4	Not Hot									
K.E.	Med.	60	4	Hot			x	x				x	
J.M.	Lg.	65	4	Hot			x	x	x	x			
E.B.	Lg.	70	.5	Hot	x	x	x	x	x	x	x		
J.M.	Med.	75	.25	Hot	x		x	x					
J.A.	Lg.	75	.5	Hot				x				x	

\* He-Head; Sh-Shoulder; Ba-Back; Ch-Chest; Th-Thigh; Le-Leg; Ar-Arm;  
Hd-Head; Ft-Feet.

frequent comments dealt with the restriction the hood imposed on turning the head (12 comments), difficulty in using communications equipment when the hood was worn (8), the uncomfortable tie string (7), and visibility restrictions (5).

Closures. Thirty-one people made comments on the suit closure; 22 dealt with the zipper closure. Of those relating to the zipper, 14 indicated that the waterproof zipper on the standard suits worked improperly. Negative comments were not received about the functioning of the zipper on the Mod I suits. There were one or two comments requesting tighter zippers and longer zippers. The longer zippers were requested to make donning and doffing of the garment easier. The remaining nine people discussed the leg and wrist closures. Of these, six thought the closures should be improved to keep out wind and water. Two indicated that water goes down the arms when binoculars are used in wet conditions.

Physical Wear. Three people stated that knee patches were required to improve the life of the suit because of excessive wear in knee areas while deck duties are performed.

Pockets. Of the five subjects who commented on the pockets, three wanted them insulated for use as hand warmers, another simply concluded the pockets were useless, and the last thought that the pen pocket in particular was very convenient.

Drying. Nine comments concerned drying the suits after they were worn. Personnel indicated that the suits took from 4 to 24 hours to dry depending upon how wet they were.

Laundering. Comments indicated that no one laundered suits. Some indicated that cleaning instructions should be provided with the suits.

Accessories. We learned that during the course of the study accessories worn with the suits ranged from sneakers to insulated boots for footwear and from bare hands to Arctic gloves for handwear. What a person wore with the suits was left to his own discretion and was limited to what was available at the particular activity.

#### ACTIVITY SUMMARY REPORTS

Summary reports from the various activities taking part in the trials indicated the following:

1. The Mod I SDES (experimental suit) provided more warmth than the Interim SDES (standard suit).
2. The suits should be made larger. In general the legs, sleeves and the trunk area should be lengthened.
3. The non-waterproof slide fastener on the experimental suits was more reliable than its waterproof counterpart on the standard suits.

4. The waterproof characteristic of the slide fastener on the standard suits was compromised because of failures of these zippers.

5. The hood design of both SDES could be improved to enhance vision and hearing and to reduce the restrictive nature of the tie cord.

6. Ventilation could be improved to minimize perspiration while working in the coverall.

7. Knee area should be reinforced.

8. Closures around head, ankles, and wrists could be improved.

9. An inflatable collar should be provided to keep the head of an unconscious person out of water in a man-overboard-type situation.

10. All activities that reported indicated that the Mod I SDES was superior to any anti-exposure suit presently being worn.

#### DISCUSSION OF RESULTS

##### Participating Personnel

Personnel taking part in the evaluation provided a good representation of those expected to wear the SDES. Most were young enlisted men or officers of average size. A sufficient number of personnel (40) took part in the evaluation which provided statistical validity to the results.

##### Duties Performed

Submarine Personnel. The duties of these personnel which were performed most frequently (lookout, topside watch, and OOD) required very little physical work and mobility, but the ability to see without restriction and use phone communications was important. Only when performing deck duties in port would personnel be required to perform much physical work and need good mobility.

Coast Guard Personnel. Search and rescue operations conducted by these personnel demand a great amount of physical work and mobility. Thus, any severe restrictions of body movement by the clothing could seriously compromise the effectiveness of these men.

##### Wear Data and Suit Preference

Wear data indicate that both suit types were worn for sufficient time periods, 1,478 and 1,120 hours for the experimental and the interim standard SDES respectively, for personnel to make significant observations as to their functional performance and to indicate their suit preference.

As was reported previously, a substantial majority (73%) preferred the Mod I SDES to the Interim SDES.

## Functional Performance

Cold Exposure. For an equivalent temperature range (0 to 35°F) the Mod I SDES provided substantially better cold protection than its interim counterpart. Over a 0 to 35°F temperature range, 60% of personnel who wore the Mod I SDES reported not being cold whereas only 20% who wore the Interim SDES indicated they were not cold.

Regardless of suit type those people who were cold indicated the head area (57 and 60%) most often as being the cold part of the body. The area mentioned next for both suits was the legs (36 to 50%).

It appears then that, although the Mod I SDES provides better cold protection than the Interim SDES, they both have the same weaknesses. Predominant cold spots occurred at the head and legs for both suits and the presence of wind and rain appeared to reduce the effective protection provided by both suit types.

Topside Protection. The data indicate that the Mod I SDES provided better topside protection than the Interim SDES (68 versus 52%), but the difference was not as substantial as occurred for cold protection. The protective characteristics of both suits were considered inadequate when the suits were exposed to rain, green water or water spray. As occurred for cold protection, the head area was mentioned most often as not being adequately protected for either suit, with the chest and leg areas mentioned second in frequency.

Although the Mod I suit provides better topside protection than the Interim SDES, they have the same weaknesses. Improved closures or seals in the neck, arm, and leg areas are required to provide better protection against water penetration.

Warm Temperatures. Respondents (68 to 72%) felt hot to about the same degree with either suit type over the temperature range of 40 to 75°F. For both suit types the chest area was indicated most often (87 to 88%) as being hot; with other body areas, such as the back, arms, legs and shoulders, being mentioned almost as frequently with either suit.

Although the Mod I suit has more bulk than the Interim SDES, both appeared equivalent as regards wear in relatively warm temperatures. The relative impermeability of both ensembles was similar and was probably more important than the mere bulk insulation in either suit in preventing adequate ventilation under warm temperature conditions.

Immersion Protection. Based upon limited testing by the Coast Guard activity, both suit types provided the same protection under immersion conditions (45°F water temperature - 1.5 hours of exposure). The need for a flotation collar as recommended is questionable since life preservers are supposed to be worn with the suits.

Personnel Comments. The suit size, hood and neck areas, and zipper closure were discussed most frequently by the participants. Most felt that: both suit types were smaller than the size designation; the sealing at the neck area was inadequate allowing wind and water to penetrate the suit at this point; the method of securing the hood was inadequate, restrictive, and affected vision and telephone communications; and the waterproof zipper closure on the interim suit was unreliable and should be discarded. Other comments were to reinforce the knee areas with patches and insulate the pockets. It was also noted that drying times can be quite long (up to 24 hours), cleaning instructions should be provided with the suits, and accessory items worn with the suit can be quite variable.

Activity Summary Reports. No new information was received in these reports, which merely reaffirmed the remarks of the test personnel. There was a decided preference for the Mod I SDES over the Interim SDES and all activities indicated that either type of suit was better than anything previously available. However, they did feel some improvements could be made in the following areas:

1. Sizing
2. Closures
3. Hood Design
4. Reinforcement of Knee Area
5. Buoyancy

#### CONCLUSIONS

The Navy Clothing and Textile Research Facility has developed a new Mod I Submarine Deck Exposure Suit which provides increased buoyancy and thermal protection while reducing the cost of construction by replacing an expensive waterproof slide fastener with a more conventional one used as part of the front entry closure.

The Type B SDES prototype was found to rank better in wet/cold protection when the garment was physiologically tested against a Type A SDES prototype and the Interim SDES in NCTRF's Air-Sea Environmental Temperature Laboratory. (The Interim SDES is currently stocked aboard Navy submarines.) The dry-cold tests performed at the Laboratory indicated, however, that the additional insulation of the type A and B SDES prototypes does not increase protection when tested in a 20°F temperature with an 18 mph wind velocity.

The Mod I SDES was found to have 9 lbs. more inherent buoyancy than the Interim SDES when tested for static buoyancy in the NCTRF marine pool.

When tested against the Interim SDES in the marine pool with human test subjects wearing insulated gloves and boots, the Mod I SDES had 20 lbs. more buoyancy. Much of this increased buoyancy was due to initially trapped air bubbles and to the buoyancy of the insulated gloves and boots. Much of this buoyancy dissipated as the air bubbles escaped the suit.

The Mod I SDES and the Interim SDES collected 23.1 lbs. and 25.6 lbs. of water, respectively, while immersed in the marine pool during the man-in-the-suit buoyancy tests. Even after the water was drained as much as possible, the Mod I SDES retained 4.9 lbs. and the Interim SDES retained 5.7 lbs. This clearly indicates that the expensive waterproof slide fastener of the Interim SDES was of little value.

The field evaluation of the Mod I SDES conducted aboard four Navy submarines and at a Coast Guard (CG) station established that the Mod I SDES functioned better in cold weather (0 - 32°F) and provided more topside protection than the Interim SDES currently used aboard submarines. The CG test personnel reported that the Mod I SDES was superior to any anti-exposure clothing previously used.

Test personnel reactions were identical to both SDES when worn in relatively warm temperatures. Both suits gave good protection against wet cold weather. Future suit designs should improve all closures, particularly in the neck and hood areas.

The sizing on both suits was unsatisfactory. The torso, leg and arm lengths were reported as being insufficient.

A limited 1-1/2-hour immersion test conducted by CG test personnel in water temperature of 45°F indicated that the insulation in each suit provided adequate protection. No discomfort occurred in chest, leg and ankles for either suit. Cold spots did occur at wrists and ankles for both suits. These areas could not be made water-tight. Also, since life preservers should be worn with these suits, the CG test subjects' recommendation for a flotation collar is unnecessary. Use of the conventional non-waterproof brass slide fastener did not compromise protection in the Mod I SDES.

Editor's Note: Clothing patterns have already been redesigned to increase leg, arm and torso dimensions. The conventional non-waterproof brass zipper has replaced the waterproof slide fastener.

This project has been completed and a new study would have to be initiated to improve all closures, develop a new hood configuration, and redesign the neck area.

Appendix A. SDES Questionnaire Form

INFORMATION SHEET

EXPERIMENTAL, BUOYANT, INSULATED SUBMARINE DECK EXPOSURE COVERALL (PVC) (MODEL I)

The experimental, Model I, polyvinyl, buoyant, insulated, submarine-deck coverall was developed by the Navy Clothing and Textile Research Facility to improve the submariner's protection against cold/wet environments. The new coverall will also provide some buoyancy if you fall over the side into the water.

You will test one experimental orange color coverall, size medium, and one interim standard orange color coverall to be worn when topside. You will wear both coveralls over a 90-day period after which time you will complete the attached questionnaire.

Please read the questionnaire when the coveralls are issued to you so you will have a familiarity with the type of information desired.

Remember, you are one of a small group of personnel who has been selected to determine whether or not the experimental coverall will provide improved protection against cold and wet conditions topside. The comfort and fit of the coverall are also very important. Candid responses to the questionnaire are required.

Remember, the Model I submarine deck exposure coverall is designed to provide emergency buoyancy only. The garment will float the weight of a man, but to properly support the head, a standard Kapok-style life jacket must be worn. The proper boots and mittens to wear with the new coveralls are the items covered by national stock numbers in 9-D8430-00-913-3409 and 9-D8415-00-965-1752 series.

A log sheet is provided with each questionnaire to be filled out by you each time you wear the standard or experimental coveralls. This log sheet, which would be returned with each questionnaire, will help you in completing the questionnaire at the end of the evaluation.

QUESTIONNAIRE

EXPERIMENTAL, BUOYANT, INSULATED SUBMARINE DECK EXPOSURE COVERALL (MODEL I)

NAME/RATE \_\_\_\_\_

NAME OF SUBMARINE \_\_\_\_\_

AGE \_\_\_\_\_ HEIGHT \_\_\_\_\_ WEIGHT \_\_\_\_\_

NORMAL JUMPER SIZE \_\_\_\_\_ DUNGAREE SIZE \_\_\_\_\_

EXPERIMENTAL SDES COVERALL NUMBER \_\_\_\_\_

DATE ISSUED \_\_\_\_\_ DATE TEST ENDED \_\_\_\_\_

ESTIMATE HOW MANY HOURS WAS EACH SDES WORN: Standard \_\_\_\_\_ Hours

Experimental \_\_\_\_\_ Hours

1. What major duties were performed when you were wearing the coveralls?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2. What size coveralls were you issued for the test?

Standard \_\_\_\_\_ Experimental \_\_\_\_\_

3. In comparison to the standard coverall issued, what was your reaction to the experimental coverall when you first put it on?

More comfortable \_\_\_\_\_  
Same \_\_\_\_\_  
Less comfortable \_\_\_\_\_

4. What was lowest temperature that you experienced wearing the two coveralls?

Standard \_\_\_\_\_ Experimental \_\_\_\_\_

5. How long were you exposed to this low temperature?

Standard\_\_\_\_\_ Experimental\_\_\_\_\_

6. Did you feel cold at the lowest temperature in either coverall?

Yes\_\_\_\_\_ No\_\_\_\_\_

6A. Were there any other factors such as wind, rain, snow or green water present?

Yes\_\_\_\_\_ No\_\_\_\_\_ Which factor\_\_\_\_\_.

7. If Yes, which coverall?

Experimental\_\_\_\_\_ Standard\_\_\_\_\_ Both\_\_\_\_\_

8. If Yes, what parts of the body felt cold?

Experimental: Arms\_\_\_\_\_ Legs\_\_\_\_\_ Chest\_\_\_\_\_ Head\_\_\_\_\_ Back\_\_\_\_\_

Shoulders\_\_\_\_\_ Thighs\_\_\_\_\_

Standard: Arms\_\_\_\_\_ Legs\_\_\_\_\_ Chest\_\_\_\_\_ Head\_\_\_\_\_ Back\_\_\_\_\_

Shoulders\_\_\_\_\_ Thighs\_\_\_\_\_

9. What was the highest temperature that you experienced wearing the two coveralls?

Experimental\_\_\_\_\_ Standard\_\_\_\_\_

10. How long were you exposed to this high temperature?

Experimental\_\_\_\_\_ Standard\_\_\_\_\_

11. Did you feel hot at the highest temperature? Yes\_\_\_\_\_ No\_\_\_\_\_

12. If Yes, which coverall? Experimental\_\_\_\_\_ Standard\_\_\_\_\_ Both\_\_\_\_\_

13. If Yes, what parts of the body felt hot?

Experimental: Arms\_\_\_\_\_ Legs\_\_\_\_\_ Chest\_\_\_\_\_ Head\_\_\_\_\_ Back\_\_\_\_\_

Shoulders\_\_\_\_\_ Thighs\_\_\_\_\_

Standard: Arms\_\_\_\_\_ Legs\_\_\_\_\_ Chest\_\_\_\_\_ Head\_\_\_\_\_ Back\_\_\_\_\_

Shoulders\_\_\_\_\_ Thighs\_\_\_\_\_

14. Did the coveralls provide protection topside? Yes \_\_\_\_\_ No \_\_\_\_\_

15. If No, which coverall and under what conditions was protection inadequate?

Experimental: Green water \_\_\_\_\_ Rain \_\_\_\_\_ Snow \_\_\_\_\_ Spray \_\_\_\_\_

Other (explain) \_\_\_\_\_  
\_\_\_\_\_

Standard: Green water \_\_\_\_\_ Rain \_\_\_\_\_ Snow \_\_\_\_\_ Spray \_\_\_\_\_

Other (explain) \_\_\_\_\_  
\_\_\_\_\_

16. If No, what parts of the body were not protected:

Experimental: Arms \_\_\_\_\_ Legs \_\_\_\_\_ Chest \_\_\_\_\_ Head \_\_\_\_\_ Back \_\_\_\_\_

Shoulders \_\_\_\_\_ Thighs \_\_\_\_\_ Other \_\_\_\_\_

Standard: Arms \_\_\_\_\_ Legs \_\_\_\_\_ Chest \_\_\_\_\_ Head \_\_\_\_\_ Back \_\_\_\_\_

Shoulders \_\_\_\_\_ Thighs \_\_\_\_\_ Other \_\_\_\_\_

17. Which coverall would you prefer?

Experimental \_\_\_\_\_ Standard \_\_\_\_\_ Either \_\_\_\_\_

18. What changes would you recommend for the Experimental Coveralls?  
(Use back of page for additional comments.)  
\_\_\_\_\_  
\_\_\_\_\_

19. Please fasten this questionnaire to the experimental coverall you wore and forward to:

Officer in Charge  
Navy Clothing and Textile Research Facility  
(Code 31)(Mr. John Silvia)  
21 Strathmore Road  
Natick, Massachusetts 01760

#### ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the other members of this project, Mr. J. Shampine, Mr. R. Keene, and especially Mr. S. Gianola, whose initial foresight recognized the limits of protective parameters of the initial polyvinyl-chloride-lined exposure suit (PVCES).

We also wish to express thanks for the considerable time and effort expended by CDR C. Lord, Supply Officer, USS FULTON (AS-11), who coordinated the submarine study, Mr. B. Raia, USCG representative at the Facility and Mr. R. Buotte, CO, Pt. Allerton Station, Hull, Massachusetts, who coordinated the Coast Guard study.

Finally, we wish to thank all the officers and men of the various test activities, especially the test personnel who spent many long hours in accumulating test data which this report is based on.